

What is claimed is:

- 1 1. A method of calibrating a positioning stage, comprising the steps of:
  - 2 (a) placing a substrate on the positioning stage, the substrate having a contrast film above a  
3 portion thereof, with at least one pattern at a predetermined location above the substrate,  
4 corresponding to a predetermined location on the positioning stage if the positioning stage has  
5 zero offset from a registration position;
  - 6 (b) applying a beam to a position where the pattern on the substrate would be located if the  
7 positioning stage has zero offset;
  - 8 (c) measuring at least one of the group consisting of reflected, transmitted and scattered  
9 portions of the beam; and
  - 10 (d) detecting whether the positioning stage has a non-zero offset based on the measured  
11 portion of the beam.
- 1 2. The method of claim 1, wherein the measured portion of the beam has a first frequency  
2 distribution if the positioning stage has a zero offset, and a second frequency distribution if the  
3 positioning stage has a non-zero offset.
- 1 3. The method of claim 1, further comprising:
  - 2 (e) moving the positioning stage if an offset is detected;
  - 3 (f) repeating steps (b), (c), (d) and (e) until no offset is detected; and
  - 4 (g) determining a magnitude and direction of the offset of the positioning stage based on a  
5 total distance and direction the positioning stage is moved.
- 1 4. The method of claim 1, wherein the beam is one of the group consisting of a Microwave,  
2 Infrared, Visible, UV, Xray, or Electron beam.
- 1 5. The method of claim 1, wherein the substrate is a semiconductor wafer, and the contrast  
2 film comprises at least one of the group consisting of photoresist, metal, oxide, and nitride.
- 1 6. The method of claim 1, wherein the substrate is an etch modified substrate.

- 1 7. The method of claim 1, wherein the substrate comprises a second film on at least a  
2 portion of the first film, and the method includes:  
3 measuring reflected, transmitted or scattered portions of the beam from the second film;  
4 and  
5 detecting whether the positioning stage has an offset based on the measured portion of the  
6 beam reflected, transmitted or scattered portions from the first film and the measured portion of  
7 the beam reflected, transmitted or scattered portions from the second film.
- 1 8. The method of claim 7, wherein the first film is a silicon oxide, and the second film is a  
2 photoresist
- 1 9. The method of claim 1, wherein the substrate includes a second pattern disposed at a  
2 different angular position on the substrate from the first pattern, the method further comprising:  
3 determining a translation vector separating the first and second patterns; and  
4 detecting an angular offset of the positioning stage, based on the translation vector.
- 1 10. The method of claim 1, wherein the substrate is a monitor wafer, the method further  
2 comprising, before step (a), the steps of:  
3 depositing the contrast film on a bare semiconductor wafer; and  
4 etching the pattern in the contrast film, to form the monitor wafer.
- 1 11. The method of claim 1, wherein the pattern includes a plurality of rectangles arranged  
2 around a perimeter of the substrate.
- 1 12. A system for calibrating a positioning stage, comprising:  
2 a substrate adapted to be placed on the positioning stage, the substrate having a contrast  
3 film above a portion thereof, with at least one pattern at a predetermined location above the  
4 substrate, corresponding to a predetermined location on the positioning stage if the positioning  
5 stage has zero offset from a registration position;  
6 a beam source that applies a beam to a position where the pattern on the substrate would  
7 be located if the positioning stage has zero offset;

8 a sensor for measuring at least one of the group consisting of reflected, transmitted and  
9 scattered portions of the beam; and

10 means for detecting whether the positioning stage has a non-zero offset based on the  
11 measured portion of the beam.

1 13. The system of claim 12, wherein the measured portion of the beam has a first frequency  
2 distribution if the positioning stage has a zero offset, and a second frequency distribution if the  
3 positioning stage has a non-zero offset.

1 14. The system of claim 12, wherein the beam includes at least one of the group consisting of  
2 a Microwave, Infrared, Visible, UV, Xray, or Electron beam.

1 15. The system of claim 12, wherein the contrast film comprises at least one of the group  
2 consisting of photoresist, metal, oxide, and nitride.

1 16. The system of claim 12, wherein the substrate is an etch-modified substrate.

1 17. The system of claim 12, wherein:  
2 the substrate comprises a second film on at least a portion of the first film;  
3 the sensor measures reflected, transmitted or scattered portions of the beam from the  
4 second film; and  
5 the detecting means determines whether the positioning stage has an offset based on the  
6 measured portions of the beam reflected, transmitted or scattered from the first film and the  
7 measured portions of the beam reflected, transmitted or scattered from the second film.

1 18. The system of claim 17, wherein the first film is a silicon oxide, and the second film is a  
2 photoresist

1 19. The system of claim 12, wherein the substrate includes a second pattern disposed at a  
2 different angular position on the substrate from the first pattern, the system further comprising:  
3 means for determining a translation vector separating the first and second patterns; and  
4 means for detecting an angular offset of the positioning stage, based on the translation  
5 vector.

1 20. The system of claim 12, wherein the pattern includes a plurality of rectangles arranged  
2 around a perimeter of the substrate.

1 21. A monitor wafer, comprising:  
2 a semiconductor substrate; and  
3 a contrast film above the substrate, the contrast film including a plurality of positive or  
4 negative patterns of geometrical objects distributed at a plurality of respectively different angles  
5 with respect to a reference location on the substrate.

1 22. The monitor wafer of claim 21, wherein the plurality of geometrical objects includes four  
2 rectangles spaced 90 degrees apart.

1 23. The monitor wafer of claim 22, wherein the plurality of rectangles are located proximate  
2 to a circumference of the monitor wafer.

1 24. The monitor wafer of claim 21, wherein the contrast film comprises at least one of the  
2 group consisting of photoresist, metal, oxide, and nitride.

1 16. The monitor wafer of claim 21, wherein the monitor wafer includes an etch-modified  
2 substrate.

1 25. The monitor wafer of claim 21, wherein the pattern is a positive pattern, the plurality of  
2 geometrical objects includes a plurality of first rectangular contrast film portions, and the  
3 monitor wafer further includes a plurality of second rectangular contrast film portions on one or  
4 more of the first rectangular contrast film portions.

1 26. The monitor wafer of claim 25, wherein each second rectangular contrast film portion is  
2 smaller than the corresponding contrast film portion on which that second rectangular contrast  
3 film portion is located.

1 27. The monitor wafer of claim 26, wherein the substrate is silicon, the first film is a silicon  
2 oxide, and the second film is a photoresist.